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THE CHIEF AND HIS ASSISTANTS.

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ANNOUNCEMENT.

By a recent act of Congress the Section of Vegetable Pathology has been made a Division, thereby placing it on an equal footing with the other branches of the Department. In view of the fact that the change in name necessitates the inauguration of a new series of bulletins, it seems a fitting time to modify somewhat the manner of issuing the JOURNAL. In the future, therefore, it is proposed to issue this publication at least four times a year, but instead of having it appear quarterly, as heretofore, we shall endeavor to publish it whenever there is sufficient material on hand to warrant us in so doing. There will be no changes made in the paging of the present volume, which will continue until four numbers, counting the one previous to this, are issued.

A NEW HOLLYHOCK DISEASE.

Plate III.

BY E. A. SOUTHWORTH.

Five or six years ago a very destructive disease made its appearance among seedling hollyhocks in a few large greenhouses in this country; it has since extended to various places in New York and New Jersey, and has nearly put an end to growing hollyhocks for bedding in the Government propagating houses in Washington.

Only a few firms grow hollyhocks in the greenhouse for bedding purposes, but these few are in most cases losing nearly their entire crop; and a reputable florist reports that the disease has quadrupled the price of hollyhocks in New York in the last two years. This malady is entirely distinct from either the well known hollyhock disease of England (*Puccinia malvacearum*, Mont.) which swept through the country a few years ago and destroyed many of the hollyhocks growing in gardens, or from the spot disease caused by *Cercospora althæina*, Sacc., described by Dr. B. D. Halsted in the Garden and Forest, March 26, 1890.

EXTERNAL CHARACTERS.

The fungus may attack any part of the plant: when on the leaf it occurs in the form of a brown spot, which may increase in size until the whole leaf is either diseased or withered; when on the petiole, the leaf and part of the petiole beyond the point of attack shrivel up at once; when at the base of the petiole, on the young unfolding leaves, or on the main stalk of the plant itself, the fungus quickly runs down to the root and kills the plant. Wherever the stem or petioles are attacked they shrivel up; all flow of sap is checked and the part of the plant or leaf beyond this point must succumb. If the plant is very dry, the diseased parts dry up, but if grown in a moist place the trouble is aggravated by swarms of bacteria that attack the diseased portions and, instead of drying up, the plant seems to perish by a kind of wet-rot. When the plant has attained some size and firmness of texture, the surface of the petiole or stem sinks in at the point of attack, forming a distinct flattening or even a hollow. The color of these spots varies from a light-yellowish brown to black. Frequently the centers of the spots are rust-color, becoming entirely black later.

BOTANICAL CHARACTERS.

The disease is due to a fungus closely resembling the well known bean rust [*Colletotrichium Lindemuthianum*, (Sacc. and Magnus) Brios. & Cava.], but the brown setæ or bristles which accompany the spores are much more plentiful than in the bean fungus. No published record of the fungus could be found and I have designated it *Colletotrichium althææ.** In structure the fungus resemles a *Glœosporium* except for the presence of the bristles in the fruit pustules. The spores of *Colletotrichium* in general are either acicular and curved or oblong. This belongs to the latter class.

The basidia and spores are formed beneath the cuticle, which is finally rutured (fig. 5); the setæ appear after the basidia but very early in the history of the fungus. On the older spots they may become so numerous as to make the pustules appear like minute black tufts of hair, and to give the center of the spots on the stems a black color.

The spores, produced by constriction from the stalks or basidia (fig. 2), are unicellular, sometimes becoming once septate at the time of germination. They germinate quickly in nutrient solutions, and by the use of a mixture of hollyhock decoction in agar agar the fungus may be brought

* *Colletotrichium althææ*, n. s.—Epiphyllous and caulicolous, erumpent, forming brown spots on the leaves and light-yellowish brown to black sunken spots on the petiole and stalk. Spores irregularly oblong, frequently with a light spot in the center, granular, colorless singly, flesh-colored in mass, 11–28 by 5μ. Basidia colorless, regularly cylindrical, tapering slightly or rounded at the apex, at least slightly longer than the mature spore, borne on a thin layer of pseudo-parenchyma, simple, but may branch if placed in excess of moisture (fig. 2). Setæ dark brown, abundant, once or twice septate, usually colorless below, 60–109 by 3–5μ, appear later than the basidia.

to perfection in plate cultures. In germination (fig. 4) the spores send out one or two, rarely three, germ tubes, which are continuous at first and filled with granular protoplasm. Sometimes, probably under unfavorable conditions, a secondary spore may form on the end of the germ tube after it has grown for a short distance, and by the time this spore is formed the first spore is empty. The mycelium produced in this way frequently anastomoses, and even the spores occasionally do the same thing, only one of the anastomosing spores sending out a germ tube. In the plant the mycelium is colorless, sparsely septate, and full of vacuoles. It penetrates the cavities of the cells, running through the vessels of the wood as well as the more delicate tissues. The tissues infested by it soon collapse, the cells die, and if the fibrovascular bundles are involved, as they usually are, the ascent of sap is stopped. A few cells on the edge of the spot may usually be observed which are penetrated by the mycelium, but are not collapsed.

The germ tubes developing from the spores sown in culture media may soon become closely septate, or may develop into a mycelium in which septa are only rarely visible, becoming, however, more closely septate as it grows older. The diameter is variable, the larger and older branches being as much as three or four times as broad as the smallest. The older branches are often constricted at the septa and sometimes instead of a constriction at a septum one of the adjacent segments swells up, forming a pear-shaped expansion at the end. The mycelium is colorless at first but in culture media soon grows dark colored and the contents become filled with large oily looking drops. After two or three days it is conspicuous in culture media by its dark color. Where it radiates from a single point the dark color usually extends nearly to the circumference of the spot which is bounded by a light margin composed of the still colorless hyphæ. In about seven days from the time that the spores are sown there are fully developed spore-producing pustules containing setæ on the artificially produced mycelium. Fig. 5 shows one of these very young pustules. The character of spores, basidia, and setæ is essentially the same as on the plant; the basidia may grow a little longer and the setæ are distinctly longer than any seen on the hollyhock itself (cf. figs. 1 and 3). The pustules may develop to a very large size, becoming half as large as a pin-head. They are perfectly black to the naked eye except where the spores form a flesh-colored mass on the top.

These cultures were undertaken with the hope of ascertaining whether the setæ actually belong to the spore-forming fungus. In case of the *Colletotrichium* on the bean this has been questioned because the setæ are frequently present in such small numbers that they are overlooked. This fact led to the idea that they might be parasites, or rather that there were two distinct fungi, one living upon the other.

In cultures I was never able to make one of these setæ germinate, but in one culture there were what seemed to be brown setæ, sending out long branches from their free ends. These could not be called true setæ, however, for they were shorter and broader than the typical ones,

and did not taper towards the ends, neither were they connected with fruiting pustules, but were borne directly on the vegetative mycelium. In fact, they seemed to be short, brown, aerial branches which had grown out into colorless hyphæ. In all the cultures wherever a pustule was produced the setæ were present, and although none of them were made from single spores, there is every reason to believe that they were pure cultures of the spores. No setæ could be discovered among them when carefully examined with the microscope, and they are so large as to be easily visible, moreover the setæ are not easily detached from the mycelium or pseudo parenchyma at the base of the pustule, and in some cases the spores were merely floated off from the pustule, so that the black setæ could scarcely have been carried with them. Besides, as had been said, a microscopical examination of the cultures revealed only the spores present. The material did not give positive evidence that the setæ and basidia sprang from the same hyphæ, but some of the very young pustules made this almost certain. In case of a similar fungus on cotton, I have seen the setæ bearing spores similar to those borne on the basidia, but nothing of the kind could be seen in this case.

The time of reproduction in artificial cultures agrees exactly with that in nature. Sowing the spores on the leaves of healthy hollyhocks in a drop of water produced well developed pustules in seven days.

Owing to the similarity of this fungus to *C. Lindemuthianum* an attempt was made to produce it on bean pods; this was unsuccessful, but inoculations similarly made with spores of *C. Lindemuthianum* produced the spores of that fungus. The inoculations were made by putting the spores in incisions made with a flamed knife, attempts to produce the bean fungus by sowing the spores on the outside having failed in former experiments.

No trouble was experienced in producing the hollyhock disease on healthy plants. For the first experiment three perfectly healthy seedlings, growing in a shallow pot in one of the Department greenhouses, were selected. There were sixteen plants in the dish and they were so close together that their leaves were in contact. The bases of the plants where the young leaf was not yet unfolded, and the points of union of the blade and petiole of full grown leaves were chosen as points of infection. In a week each of these three plants were diseased at one or more of the inoculated spots, while the other plants in the same dish were perfectly healthy except for a few spots of *Cercospora* on some of the leaves. These spots were entirely distinct from those caused by the *Colletotrichium* spores, and there was no possibility of confounding the two fungi. Later, two of these infected plants were killed by the fungus passing down from the young leaf to the base of the plant. This experiment was repeated by inoculating other plants in the same dish and was successful each time. The fungus which developed on these plants agreed in every particular with the one in Henderson's greenhouses.

GENERAL NOTES.

A number of circulars were sent out to prominent florists asking as to their experience with the disease. Our answers revealed the following facts: (1) Comparatively few florists have ever had any experience with the fungus, but wherever it has made its appearance it has been exceedingly destructive, the losses varying from 25 per cent. to the entire crop. (2) No one who grows hollyhocks entirely out of doors reported the disease, but some of those who reported it on seedlings raised in the greenhouse said it also attacked plants which were raised out of doors and had never been in the house. At Henderson's greenhouses it disappeared at first after the plants were bedded, but last year, owing probably to the wet season, the disease reappeared very violently after the plants were in bud and nearly ready to blossom, killing them root and all. Another correspondent reported that it attacked and killed his plants that were raised entirely out of doors. (3) Putting diseased plants out of doors may check the disease in some cases, but this is very uncertain. (4) Heat and moisture are very bad for the plants; as little as possible of each should be given.

Three dozen perfectly healthy plants growing out of doors in a cold frame were picked out from some Bay Ridge, L. I., nurseries and sent to Washington for experiments with infection. They were not carefully taken up and consequently experiments were delayed until they should recover from the set-back in growth they had received. Half of the plants were potted and put in one of the Department greenhouses while the other half were planted out of doors. Instead of recovering, and before any attempts at infection were made, the plants in the greenhouse were attacked with the fungus and were dead in two weeks. Those out of doors also became diseased, but not so badly and lingered along for some time. These plants had never been in a greenhouse; they were sowed out of doors the fall before, and had lived through the winter in a cold frame. They did not become diseased from contact with other diseased plants, for except the fungus which was produced on the seedlings already mentioned, there was none in the Department grounds, and these plants were kept in another house at some distance from the first. This would look as if the fungus could more readily attack plants whose vitality is in some way decreased, and is a hint to hollyhock growers as to the manner of transplanting.

Raising plants indoors is almost necessary if the demand for bedding plants is to be met in the spring, and consequently those who wish to raise them for the spring trade must either have some remedy for the disease or give up the business. For the purpose of ascertaining whether fungicides which have been of value in other diseases would also answer in this, the following experiment was made in Henderson's greenhouse. Three hundred plants which had been taken out of the greenhouse and put out of doors were brought in and repotted without disturbing the roots. All the diseased leaves were picked off; they were then arranged in three lots of 100 each and placed far enough apart so

that no two plants were in contact. One hundred were left untreated; 100 were sprayed every other day with the ammoniacal copper carbonate solution, and 100 with Bordeaux mixture, 4 pounds of lime to 6 of copper. Only the upper sides of the leaves were sprayed at first, but later the spray was applied to both sides. The results of the experiment were only moderately satisfactory, due in some measure at least to this early exposure of the under sides of the leaves, but in June the plants were visited and the effects of the Bordeaux mixture could be seen for some distance, the lot thus treated being much more vigorous than the other two. The effects of the copper carbonate were not very apparrent. There were diseased plants among those treated with Bordeaux mixture, but the foreman of the greenhouses was so encouraged by the results that he had decided to spray the plants out of doors as well.

An experiment made at the Department by Mr. Galloway, on a smaller scale, was less successful. Plants which were dipped in the mixture developed the disease, but there is sufficient encouragement for florists to try the mixture thoroughly another year, taking especial care to spray both sides of the leaves. It is of prime importance to completely clear the greenhouses of all diseased plants and raise an entirely fresh stock. The spraying should begin as soon as the first leaves come out, and be repeated every other day.

For applying the solutions on a small scale, any force-pump will answer, providing it is supplied with a suitable nozzle, such as the Vermorel or Japy. These can now be obtained from nearly all the large firms who deal in florists' supplies. Where the cultivation of the hollyhock is made an extensive business, the knapsack form of sprayer, such as described on page 51 of the present number, will be found very serviceable for applying the remedies.

EXPLANATION OF PLATE.

PLATE III.—*Colletotrichium althææ*, n. s.

FIG. 1. Section through fruiting pustule × 500.

2. Basidia bearing spores at their apices. The branched basidium was drawn from a specimen kept in a moist place × 600.

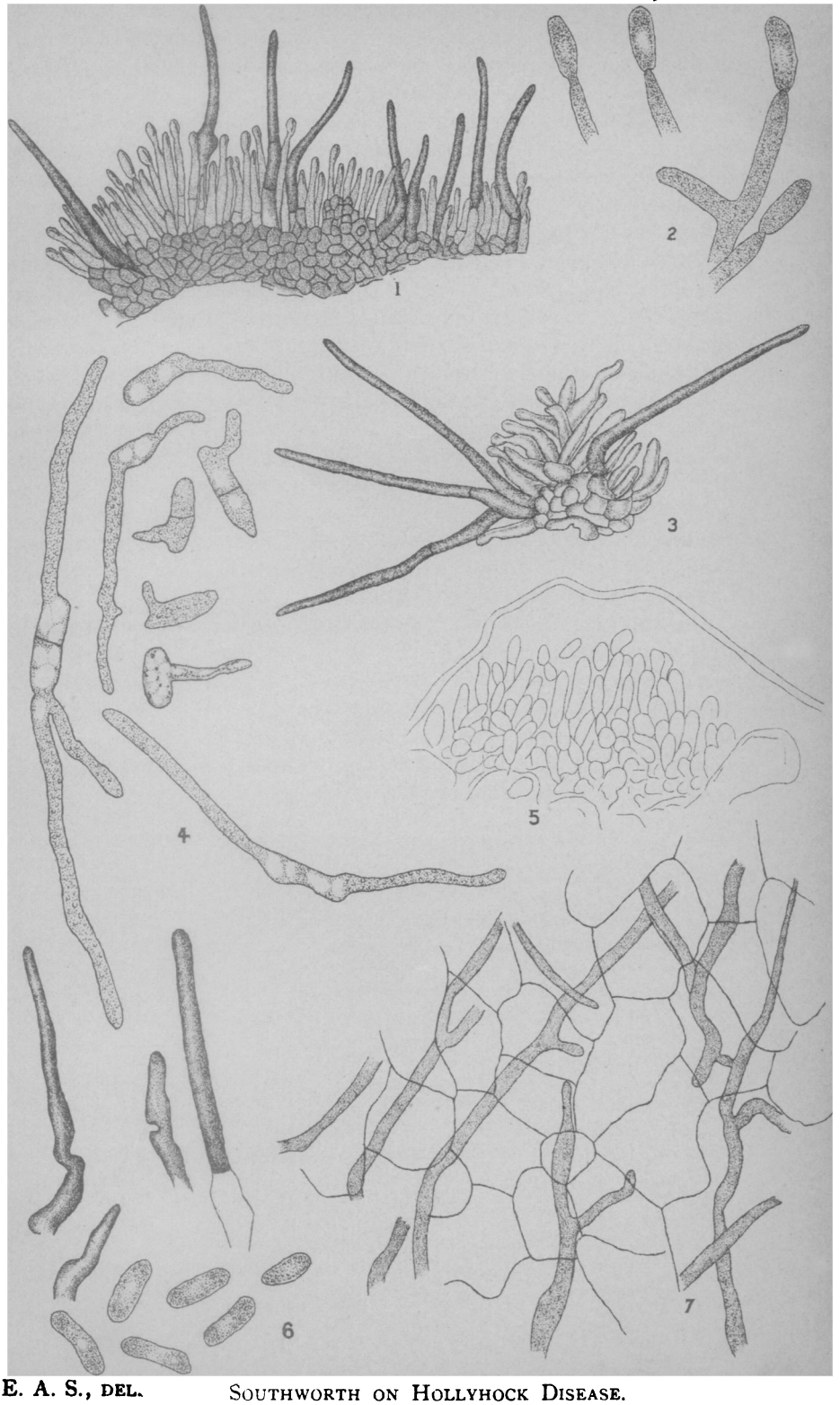
3. Small fruiting body grown on artificial substratum. It will be seen that the setæ are longer than in fig. 1, which represents the fungus on the plant, × 500.

4. Germinating spores, × 600.

5. Section through young fruiting pustule made before the epidermis had been ruptured × 600.

6. Setæ and spores × 600.

7. Mycelium in the tissue of a leaf as seen through the epidermis × 600.



E. A. S., DEL. SOUTHWORTH ON HOLLYHOCK DISEASE.